# AEROSOL POLARIMETRY SENSOR (APS)

Sensor Requirements Document (SRD)

for

NATIONAL POLAR-ORBITING OPERATIONAL ENVIRONMENTAL SATELLITE SYSTEM (NPOESS)

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# 1 SCOPE

## 1.1 IDENTIFICATION & OVERVIEW

This Sensor Requirements Document (SRD) sets forth the requirements for the Aerosol Polarimetry Sensor (APS) of the National Polar-orbiting Operational Environmental Satellite System (NPOESS).

The purpose of the APS is to retrieve specified aerosol and cloud parameters using multispectral photopolarimetry. It is anticipated that the APS will need to simultaneously measure scene radiance in orthogonal polarizations over a range of viewing angles in order to make these retrievals. These measured radiances will be processed and delivered to the users in the form of Raw Data Records (RDRs), Sensor Data Records (SDRs), and ultimately Environmental Data Records (EDRs).

## 1.2 TERMINOLOGY

The term "(TBD)", which means "to be determined", applied to a missing requirement means that the instrument contractor should determine the missing requirement in coordination with the spacecraft contractor.

The term "(TBS)", which means "to be specified", means that the spacecraft contractor will supply the missing information in the course of the contract. These serve as a placeholder for future requirements. The instrument contractor is not liable for compliance with these "placeholder" requirements, as insufficient information is provided on which to base a design.

The term "(TBR)", which means "to be refined/reviewed", means that the requirement is subject to review for appropriateness by both spacecraft contractors, and subject to revision. The instrument contractor is liable for compliance with the requirement as if the "TBR" notation did not exist. The "TBR" merely provides an indication that the value is more likely to change in a future modification than requirements not accompanied by a "TBR".

Whenever the term "contractor" appears herein without the qualifier "spacecraft" or "instrument," it shall be understood to mean "instrument contractor."

## 1.3 DOCUMENT OVERVIEW

This document, in conjunction with the General Instrument Interface Document (GIID), contains all the requirements for the APS. Sensor performance requirements are contained in this SRD and the APS interface requirements are found in the GIID.

The contractor should use this SRD, in conjunction with the GIID, as the technical basis of a proposed sensor specification.

### 1.3.1 REQUIREMENT WEIGHTING FACTORS

The requirements stated in this specification are not of equal importance or weight. The following three paragraphs define the weighting factors incorporated in this specification.

a. *Shall* designates the most important weighting level; that is, mandatory. Any deviations from these contractually imposed mandatory requirements require the approval of the APS contracting officer.

b. S*hould* designates "requirements" which are requested, but are not mandatory. Unless required by other contract provisions, noncompliance with the *should* paragraphs does not require approval of the contracting officer, but does require technical substantiation.

c. *Will*/*may* designates the lowest weighting level. These *will or may* "requirements" designate intent and are often stated as examples of acceptable designs, items, and practices. Unless required by other contract provisions, noncompliance with the *will* or may paragraphs does not require approval of the contracting officer and does not require documented technical substantiation.

## 2 APPLICABLE DOCUMENTS

In addition to the NPOESS Technical Requirements Document (TRD), the documents listed in section 2 of the NPOESS General Instrument Interface Document (GIID) and the GIID itself, form a part of this SRD to the extent specified therein. In the event of conflict between the documents referenced therein and the contents of this specification, the contents of this specification shall be the superseding requirements. Tailoring of documents in section 2 of the GIID is (TBR).

The documentation listed in section 2.0 of the GIID follows an approach of minimum specs and standards. The contractor may add to, or revise, the documents listed in section 2.0 of the GIID, in coordination with the government.

## 3 SENSOR REQUIREMENTS

### 3.1 DEFINITION

### 3.1.1 APS DESCRIPTION

SRDA3.1.1-1
The APS shall be capable of measuring radiance in orthogonal polarizations at multiple wavelengths in the 0.4 to 2.4 micron region, and at multiple angles within the sensor FOV being ±60 degrees about nadir in the along-track direction.

SRDV3.1.1-2
The contractor shall determine the sensor architecture, that is, the number of instruments and discrete modules comprising the sensor suite.

The contractor is responsible for determining the sensor characteristics and performance requirements needed to satisfy a specified subset of the Environmental Data Record (EDR) requirements. (See Sec. 3.2.1)

### 3.1.2 TOP-LEVEL APS FUNCTIONS

SRDA3.1.2-1
At a minimum, each APS instrument shall perform the following functions throughout its operational lifetime:

- acquisition of all sensor-related data, including calibration data, necessary to meet the EDR requirements allocated to the APS
- acquisition of sensor health, status, and thermal data
- generation of High Rate Data (HRD)/Stored Mission Data (SMD) data packets containing scene radiance, calibration, monitoring, health, and status data
- reception of command and control data
- accommodation of uplinked flight software package revisions

### 3.1.3 SENSOR MODES

SRDA3.1.3-1
The APS shall implement the modes specified in section 3.1.3 of the GIID.

SRDA3.1.3-2
In addition to the GIID-specified modes, the APS shall implement an OUTGASSING Mode.

One or more CALIBRATION Modes may be used , if such modes are necessary to meet requirements.

#### 3.1.3.2 APS-Unique Mode and Submode Requirements

3.1.3.2.1 OUTGASSING Mode

Instrument subassemblies or components are powered on in the outgassing mode only as necessary to facilitate outgassing, not to provide valid Earth scene or calibration data. In the OUTGASSING mode during the early days of the mission, the instruments are not required to operate.

SRDA3.1.3.2.1-1
The APS shall be capable of exercising this mode at any time during the mission when decontamination is required.

SRDA3.1.3.2.1-2
In this mode, the optics, cooler, and other critical components shall be protected from contamination.

3.1.3.2.2 CALIBRATION Mode(s)

In the CALIBRATION mode(s), the APS views a calibration source and acquires calibration data. Collection of operational Earth scene radiance data may be suspended in this mode. In this mode, the functional configuration and/or operation of an APS instrument may be modified relative to the OPERATIONAL mode configuration and/or operation. For example, the scan may be modified so that an APS instrument views an external calibration source such as the sun or moon.

SRDA3.1.3.2.2-1
The APS shall be capable of performing sensor calibration without any spacecraft maneuvers.

### 3.1.3.3 Mode Documentation

SRDA3.1.3.3-1
The complete set of APS modes deemed necessary by the contractor shall be defined in the APS System Performance Specification or APS Unique Instrument Interface Document (UIID).

SRDA3.1.3.3-2
All commands relating to mode configuration and re-configuration shall be defined in the APS UIID.

## 3.1.4 OPERATIONAL CONCEPT

SRDA3.1.4.2-1
The APS shall meet all requirements enumerated in the APS operational concept as described in section 3.1.4 of the GIID therein.

SRDA3.1.4.2-2
The APS shall meet specified EDR performance from data obtained for the 2130 (ascending) orbit as described in paragraph 3.1.4.3 of the GIID. For the other orbits described in paragraph 3.1.4.3 of the GIID, except for orbits within about 30 (TBR on integrating contractor) minutes of noon for a morning orbit, and 20 (TBR on integrating contractor) minutes of noon for an afternoon orbit, performance is not required to meet prescribed thresholds.

## 3.1.5 MISSIONS

The primary mission of the APS is to provide high quality radiometric data as a function of polarization in the visible through short-wave infrared (SWIR) spectral regions in support of climate studies. In addition, the APS shall support worldwide DoD and civilian operations by augmenting and enhancing applicable Visible & Infrared Imaging Radiometer Suite (VIIRS) EDRs.

## 3.2 SENSOR SUITE CHARACTERISTICS

### 3.2.1 PERFORMANCE CHARACTERISTICS

The data product-level requirements of the EDRs assigned to the APS determine the performance characteristics of the APS. The contractor will develop the applicable EDR algorithms and use these to flowdown instrument level performance requirements from the EDR level requirements

SRDA3.2.1-1
APS shall meet its performance requirements while in the OPERATIONAL mode.
The performance requirements in the Operational Mode shall be (TBR). Requirements for other modes must be consistent with the functions and purposes of this mode as described in Section 3.1.3 above and/or in the GIID.

#### 3.2.1.1 EDR Requirements

SRDA3.2.1.1-1
The APS design, in conjunction with the APS algorithms, shall meet or exceed the environmental data record threshold requirements set forth in Section 3.2.1.1.1.
The generation and delivery of operational EDRs will be the responsibility of the NPOESS EMD contractor, not the APS contractor.

3.2.1.1.1 Primary EDRs

SRDA3.2.1.1.1-1
The APS shall satisfy all requirements set forth in section 3.2.1.1 of this document for the following “primary” EDRs:

- Aerosol Optical Thickness
- Aerosol Particle Size
- Aerosol Refractive Index, Single-Scattering Albedo, and Shape
- Cloud Particle Size Distribution

APS data may be supplemented in some cases by data derived from other NPOESS sensors, databases, and ancillary sources:

SRDA3.2.1.1.1-2
If data from another NPOESS sensor are required to meet a threshold for any EDR, the APS Algorithm Performance Specification shall identify the sensor parameters (e.g. data content, quality, and timeliness) required from the other sensors.

SRDA3.2.1.1.1-3
The APS shall meet all threshold requirements without modification of any NPOESS sensors.

SRDA3.2.1.1.1-4
Regardless of whether or not data are required from a non-APS sensor, the APS shall meet the thresholds for the EDRs listed in this section.

Requirements for each of the EDRs are listed below. The required maximum local average revisit time and maximum local refresh are not shown. For all APS EDRs, the revisit and refresh requirements are, by definition, met if the APS provides observations from the satellite nadir-track of any satellite carrying the APS.

Unless otherwise specified, attribute values are to be interpreted as upper bounds anywhere in the geographical area where measurements are obtained, including the edge of the measuring sensor field of regard. A threshold or objective is "met" or "satisfied" if the system performance value is less than or equal to the specified value. One exception is *Measurement Range*, which is not an upper bound. Another exception is HCS, a nadir value which is allowed to grow geometrically in a natural fashion off nadir.

Unless otherwise specified, a percentage appearing as a value for an attribute is to be interpreted as the percentage of the true value of the attribute.

Vertical height is measured by height above mean sea level. A value of zero km for height refers to mean sea level.

Mapping uncertainty applies to the HCS at the nadir-viewed location for which the EDR is reported, and does not apply to all of the multiple view angle measurements used in the retrieval of that EDR.

### 3.2.1.1.1.1 Aerosols

Aerosols are defined as suspensions of liquid droplets or solid particles in the atmosphere. Aerosols include, but are not limited to, smoke, dust, sand, volcanic ash, sea spray, polar stratospheric clouds, and smog. Water and ice clouds are also aerosols but, because of the frequency of their occurrence and their importance in the environment to military operations, they are addressed separately under cloud EDRs.

#### 3.2.1.1.1.1.1 Aerosol Optical Thickness

Aerosol Optical Thickness, for this EDR, is defined as the extinction (scattering + absorption) vertical optical thickness of modes 1 (~ 0.1 μm) and 2 (~ 1.0 μm) of the bimodal aerosol size distribution at multiple wavelengths within the 0.4 – 2.4 micron spectral range. The refresh requirement is to provide observations from the satellite nadir-track of any satellite carrying the APS. The requirements below apply only under clear and daytime conditions ("#" applies to total column optical depth).

Units: Aerosol Optical Thickness: Dimensionless

| Req. No. SRDA3.2.1.1. 1.1.1 | | Thresholds | Objectives |
|---|---|---|---|
| -1 | a. Horizontal Cell Size (nadir) | 10 km | 1 km |
| | b. Horizontal Reporting Interval | N/A | N/A |
| | c. Vertical Cell Size | Total Column | |
| -2 | 1. 0 - 2 km | N/A | 0.25 km |
| -3 | 2. 2 - 5 km | N/A | 0.5 km |
| -4 | 3. > 5 km | N/A | 1 km |
| -5 | d. Vertical Reporting Interval | N/A | (TBD) |
| -6 | e. Horizontal Coverage | Nadir Track | Nadir Track |
| -7 | f. Vertical Coverage | 0 - 38 km | 0 - 50 km |
| -8 | g. Measurement Range # | 0.0 to 5.0 | 0.0 to 10.0 |
| | h. Measurement Accuracy | | |
| -9 | 1. Over ocean | Greater of 0.02 or 7% | Greater of 0.01 or 5% |
| -10 | 2. Over land | Greater of 0.04 or 10% | Greater of 0.03 or 7% |
| | i. Measurement Precision # | | |
| -11 | 1. Over ocean | 0.01 | 0.005 |
| -12 | 2. Over land | 0.03 | 0.02 |
| -13 | j. Long-term Stability | 0.01 | 0.005 |
| -14 | k. Mapping Uncertainty # | 4 km | 1 km |
| -15 | n. Minimum Swath Width (All other EDR thresholds met) | Nadir track | Nadir Track |
| | | | |

3.2.1.1.1.1.2 Aerosol Particle Size

The size denotes a measurement of the bimodal size distribution of the aerosol population in terms of the effective radius $r_e$ and effective variance $v_e$ of each mode. The effective radius is the ratio of the third moment of the aerosol size distribution to the second moment. The Effective Variance, $\nu_{e,}$ characterizes the width of the size distribution, n(r), and is calculated as an area weighted average of the normalized variance as given by the following expression:

$$\nu_e = [\int(r - r_{eff})^2 \pi r^2 n(r)dr] / [r_{eff}^2 \int \pi r^2 n(r)dr]$$

It also can be expressed in terms of the second, third, and fourth moments of the size distributions:

$$\nu_e = [(m_4 m_2) / m_3^2] - 1$$

Where $m_n$ denotes the $n^{th}$ moment of the size distribution.

. The refresh requirement is to provide observations from the satellite nadir-track of any satellite carrying the APS. The requirements below apply only under clear and daytime conditions and are only applicable to sub-satellite pixels. (# -applies to the average column size distribution).

Units: Aerosol Particle Size: Effective radius ($r_e$) for each mode in microns.

| Req. No. SRDA 3.2.1.1.1.1.2 | | **Thresholds** | **Objectives** |
|---|---|---|---|
| -1 | a. Horizontal Cell Size (nadir) | 10 km | 1 km |
| | b. Horizontal Reporting Interval | N/A | N/A |
| | c. Vertical Cell Size | Total Column | |
| -2 | 1. 0 - 2 km | N/A | 0.25 km |
| -3 | 2. 2 - 5 km | N/A | 0.5 km |
| -4 | 3. > 5 km | N/A | 1 km |
| -5 | d. Vertical Reporting Interval | N/A | (TBD) |
| -6 | e. Horizontal Coverage | Nadir Track | Nadir Track |
| -7 | f. Vertical Coverage | 0 - 38 km | 0 - 50 km |
| -8 | g. Measurement Range | 0 to 5 µm | 0 to 10 µm |
| -9 | h. Measurement Accuracy | Greater of 0.1 µm or 10% | Greater of 0.05 µm or 5% |
| -10 | i. Measurement Precision | Greater of 0.05 µm or 10% | Greater of 0.05 µm or 5% |
| -11 | j. Long Term Stability | Greater of 0.05 µm or 10% | Greater of 0.05 µm or 5% |
| -12 | k. Mapping Uncertainty # | 4 km | 1 km |
| -13 | l. Minimum Swath Width (All other EDR thresholds met) | Nadir Track | Nadir Track |

Units: Aerosol Particle Size: Effective variance ($v_e$) for each mode (dimensionless)

| Req. No. SRDA 3.2.1.1.1.1.2 | | Thresholds | **Objectives** |
|---|---|---|---|
| -14 | a. Horizontal Cell Size (nadir) | 10 km | 1 km |
| | b. Horizontal Reporting Interval | N/A | N/A |
| | c. Vertical Cell Size | Total Column | |
| -15 | 1. 0 - 2 km | N/A | 0.25 km |
| -16 | 2. 2 - 5 km | N/A | 0.5 km |
| -17 | 3. > 5 km | N/A | 1 km |
| -18 | d. Vertical Reporting Interval | N/A | (TBD) |
| -19 | e. Horizontal Coverage | Nadir Track | Nadir Track |
| -20 | f. Vertical Coverage | 0 - 38 km | 0 - 50 km |
| -21 | g. Measurement Range | 0 to 3 | 0 to 5 |
| -22 | h. Measurement Accuracy | Greater of 0.3 or 50% | Greater of 0.2 or 30% |
| -23 | i. Measurement Precision | Greater of 0.1 or 40% | Greater of 0.1 or 20% |
| -24 | j. Long Term Stability | Greater of 0.2 or 40% | Greater of 0.1 or 20% |
| -25 | k. Mapping Uncertainty # | 4 km | 1 km |
| -26 | l. Minimum Swath Width (All other EDR thresholds met) | Nadir Track | Nadir Track |

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### 3.2.1.1.1.1.3 Aerosol Refractive Index, Single-Scattering Albedo, and Shape

Measurement of the real part of the refractive index *m*, and the single-scattering albedo $\omega$, of each mode of the bimodal aerosol size distribution at multiple wavelengths within the 0.4-2.4 micron spectral range; and determination whether aerosol particles are spherical or non-spherical. Non-sphericity is detected when the value $S = (Lmax\ Lmin^{-1} - 1) > 0.3$, where Lmax is the maximum dimension of the particle and Lmin is the minimum dimension of the particle. The value of S can be inferred from multi-angular measurements of the departure of scattered radiation from that expected from spherical aerosol particles. The refresh requirement is to provide observations from the satellite nadir-track of any satellite carrying the APS. The requirements below apply only under clear conditions and are only applicable to sub-satellite pixels (# - applies to the average column size distribution).

Units: Aerosol Refractive Index, *m*, for each mode, dimensionless

| Req. No. SRDA 3.2.1.1.1.1.3 | | **Thresholds** | **Objectives** |
|---|---|---|---|
| -1 | a. Horizontal Cell Size (nadir) | 10 km | 1 km |
| | b. Deleted | | |
| | c. Vertical Cell Size | Total Column | |
| -2 | 1. 0 - 2 km | N/A | 0.25 km |
| -3 | 2. 2 - 5 km | N/A | 0.5 km |
| -4 | 3. > 5 km | N/A | 1 km |
| -5 | d. Vertical Reporting Interval | N/A | (TBD) |
| -6 | e. Horizontal Coverage | Nadir Track | Nadir Track |
| -7 | f. Vertical Coverage | 0 - 38 km | 0 - 50 km |
| -8 | g. Measurement Range # | 1.3 to 1.7 | 1.3 to 1.8 |
| -9 | h. Measurement Accuracy # | 0.02 | 0.01 |
| -10 | i. Measurement Precision # | 0.01 | 0.005 |
| -11 | j. Long Term Stability | 0.01 | 0.005 |
| -12 | k. Mapping Uncertainty # | 4 km | 1 km |
| -13 | l. Minimum Swath Width (All other EDR thresholds met) | Nadir Track | Nadir Track |

Units: Aerosol Single Scattering albedo, $\omega$, for each mode, dimensionless

| Req. No. SRDA 3.2.1.1.1.1.3 | | **Thresholds** | **Objectives** |
|---|---|---|---|
| -14 | a. Horizontal Cell Size (nadir) | 10 km | 1 km |
| | b. Deleted | | |
| | c. Vertical Cell Size | Total Column | |
| -15 | 1. 0 - 2 km | N/A | 0.25 km |
| -16 | 2. 2 - 5 km | N/A | 0.5 km |
| -17 | 3. > 5 km | N/A | 1 km |
| -18 | d. Vertical Reporting Interval | N/A | (TBD) |
| -19 | e. Horizontal Coverage | Nadir Track | Nadir Track |
| -20 | f. Vertical Coverage | 0 - 38 km | 0 - 50 km |
| -21 | g. Measurement Range # | 0 to 1 | 0 to 1 |
| -22 | h. Measurement Accuracy # | 0.03 | 0.01 |
| -23 | i. Measurement Precision # | 0.02 | 0.01 |
| -24 | j. Long Term Stability | 0.02 | 0.01 |
| -25 | k. Mapping Uncertainty # | 4 km | 1 km |
| -26 | l. Minimum Swath Width (All other EDR thresholds met) | Nadir Track | Nadir Track |

Units: Aerosol Particle Shape, $S = ((L_{max}L_{min}^{-1})-1)$, dimensionless

| Req. No. SRDA 3.2.1.1.1.1.3 | | **Thresholds** | **Objectives** |
|---|---|---|---|
| -27 | a. Horizontal Cell Size (nadir) | 10 km | 1 km |
| | b. Deleted | | |
| | c. Vertical Cell Size | Total Column | |
| -28 | 1. 0 - 2 km | N/A | 0.25 km |
| -29 | 2. 2 - 5 km | N/A | 0.5 km |
| -30 | 3. > 5 km | N/A | 1 km |
| -31 | d. Vertical Reporting Interval | N/A | (TBD) |
| -32 | e. Horizontal Coverage | Nadir Track | Nadir Track |
| -33 | f. Vertical Coverage | 0 - 38 km | 0 - 50 km |
| -34 | Deleted | | |
| -35 | Deleted | | |
| -40 | g. Sphericity | Spherical/Non-spherical | Spherical/Non-spherical |
| -41 | h. Probability of Correct Typing | 90% (TBR) | 95% |
| -36 | i. Deleted | | |
| -37 | j. Deleted | | |
| -38 | k. Mapping Uncertainty # | 4 km | 1 km |
| -39 | l. Minimum Swath Width (All other EDR thresholds met) | Nadir Track | Nadir Track |

3.2.1.1.1.2 Cloud Particle Size Distribution

Cloud Particle Size Distribution is defined here as the effective radius $r_e$ and effective variance $v_e$ of a single mode particle size distribution. The effective radius is the ratio of the third moment of the size distribution to the second moment. The effective variance characterizes the width of the size distribution. The refresh requirement is to provide observations from the satellite nadir-track of any satellite carrying the APS. Requirements below are only applicable to sub-satellite pixels.

Units: Cloud Particle Size Distribution: Effective radius ($r_e$) in microns.

| Req. No. SRDA 3.2.1.1.1.2 | | **Thresholds** | **Objectives** |
|---|---|---|---|
| -1 | a. Horizontal Cell Size (nadir) | 15 km | 5 km |
| | b. Horizontal Reporting Interval | N/A | N/A |
| | c. Vertical Cell Size | N/A | N/A |
| -2 | d. Vertical Reporting Interval | 1 km | 0.3 km |
| -3 | e. Horizontal Coverage | Nadir Track | Nadir Track |
| | f. Vertical Coverage | N/A | N/A |
| -4 | g. Measurement Range | 0 to 50 µm | 0 to 80 µm |
| -5 | h. Measurement Accuracy | Greater of 1 µm or 10% | Greater of 0.5 µm or 5% |
| -6 | i. Measurement Precision | Greater of 0.5 µm or 5% | Greater of 0.3 µm or 3% |
| -7 | j. Long Term Stability | Greater of 0.5 µm or 5% | Greater of 0.3 µm or 3% |
| -8 | k. Mapping Uncertainty | 4 km | 1 km |
| -9 | l. Minimum Swath Width (All other EDR thresholds met) | Nadir Track | Nadir Track |

Units: Cloud Particle Size Distribution: Effective variance ($v_e$), dimensionless

| Req. No. SRDA 3.2.1.1.1.2 | | **Thresholds** | **Objectives** |
|---|---|---|---|
| -10 | a. Horizontal Cell Size (nadir) | 15 km | 5 km |
| | b. Horizontal Reporting Interval | N/A | N/A |
| | c. Vertical Cell Size | N/A | N/A |
| -11 | d. Vertical Reporting Interval | 1 km | 0.3 km |
| -12 | e. Horizontal Coverage | Nadir Track | Nadir Track |
| | f. Vertical Coverage | N/A | N/A |
| -13 | g. Measurement Range | 0 to 2 | 0 to 3 |
| -14 | h. Measurement Accuracy | Greater of 0.05 or 50% | Greater of 0.04 or 40 % |
| -15 | i. Measurement Precision | Greater of 0.04 or 40% | Greater of 0.03 or 30 % |

| | | | |
|---|---|---|---|
| -16 | j. Long Term Stability | Greater of 0.04 or 40% | Greater of 0.03 or 30 % |
| -17 | k. Mapping Uncertainty | 4 km | 1 km |
| -18 | l. Minimum Swath Width (All other EDR thresholds met) | Nadir Track | Nadir Track |

3.2.1.1.2 Modifications and Clarifications of EDR Requirements

The modifications and clarifications of EDR requirements in this section take precedence over any conflicting requirements or statements in section 3.2.1.1.1, Appendix D of the TRD, or the IORD, or Appendix A: Glossary.

3.2.1.1.2.1 EDR Requirements Applying Under Clear Conditions Only

For guidance purposes only, definitions of “clear” and “cloudy” appear in Section 40.1.7 of the TRD Appendix D. In this SRD, “Cloud” always means “detectable cloud” (as defined in Appendix A: Glossary).

SRDA3.2.1.1.2.1-2
The definitions of “clear” and “cloudy” shall be (TBR). Different definitions may be proposed for different EDRs.

Under cloudy conditions, the aerosol EDRs should be provided on an as-capable basis, possibly with degraded data quality and completeness.

3.2.1.1.2.2 EDR Requirements Applying Under Daytime Conditions Only

SRDA3.2.1.1.2.2-1
Requirements for the APS EDRs shall be fully met under daytime conditions. Under non-daytime conditions, these EDRs should be provided on an as-capable basis, possibly with degraded data quality and completeness.

SRDA3.2.1.1.2.2-2
The contractor shall determine the radiance levels (or solar zenith angles) in appropriate bands that will define “daytime conditions” for each of these EDRs. Daytime conditions need not be defined in the same way for different EDRs.

### 3.2.1.2 Operational SDR Requirements (TBR)

In processing RDRs into EDRs, the IDPS will generate intermediate-level satellite instrument data files, including Sensor Data Records (SDRs). SDRs are needed for retrospective processing, leading to improved methods, and for archival, for long-term sensor evaluation, or troubleshooting. SDRs will be delivered to the same user destinations as the associated EDRs, as specified in the TRD Appendix E, which lists delivery destinations of RDRs/EDRs. The generation and delivery of operational SDRs will be the responsibility of the NPOESS EMD contractor, not the APS contractor.

3.2.1.2.1 Operational SDR Content (TBR)

The NPOESS EMD contractor, not the APS contractor, will be responsible for defining the content of operational SDRs.

SRDA3.2.1.2.1-1

The APS contractor shall recommend the content of operational SDRs. The government, at its discretion, may provide this recommendation to the NPOESS EMD contractor.

At a minimum, operational SDRs will include the following information:

- SDR identification tag
- Spacecraft identification tag
- Sensor identification tag
- Flight software version number
- Data Mode (operational, calibration, early-orbit types, etc.)
- Data acquisition orbit number
- Data transmission orbit number
- Spacecraft Orientation
- Beginning Julian date and time tag
- Ending Julian date and time tag
- Ascending Node Julian date and time tag
- Identification of RDRs, databases, algorithms, and other ancillary data used to generate the SDR
- Channel identification
- Calibrated in-band Earth radiance per sample and polarization
- Calibration source radiance data
- Calibration hardware instrumentation data
- Identification of type and time of calibration data acquisition for all calibrations utilized
- Earth location (latitude/longitude) information
- Solar elevation angle (nadir)
- Lunar phase angle (nadir), if applicable
- Lunar elevation angle (nadir), if applicable
- Scan or stare index
- Beginning and end times of scan or stare
- Data sufficient to allow calculation of time tag for each sample to the nearest millisecond
- Internal sensor temperatures, voltages, and currents

#### 3.2.1.3 Operational RDR Requirements (TBR)

Because RDRs are processed into EDRs, RDRs are considered to have met their requirements when they are of an appropriate format, completeness, and quality to be adequately processed into their associated EDRs.

SRDA3.2.1.3-1
The APS shall generate data for operational RDRs.

3.2.1.3.1 Operational RDR Content (TBR)

SRDA3.2.1.3.1-1
At a minimum, operational RDRs shall include the following data:

- Channel identification
- Compression information (if used)
- Uncalibrated Earth scene radiometric data (compressed or raw)
- Calibration source raw radiometric data
- Calibration hardware instrumentation data
- Identification of type and time of calibration data acquisition for all calibrations utilized
- Sensor related data necessary for geolocation of samples
- Scan or stare index
- Beginning and end times of scan or stare
- Data sufficient to allow calculation of time tag for each sample

SRDA3.2.1.3.1-2
The APS data shall be appended to or incorporated with the following data, at a minimum, into an operational RDR at least every five minutes (spacecraft tasking):

- RDR identification tag
- Spacecraft identification tag
- Sensor identification tag
- Flight software version number
- Spacecraft related data necessary for geolocation
- Data mode (operational, calibration, early-orbit types, etc.)
- Data acquisition orbit number
- Data transmission orbit number
- Critical sensor temperatures, voltages, and currents
- Ascending Node Julian date and time tag

3.2.1.3.2 Operational RDR Format (TBR)

SRDA3.2.1.3.2-1
The RDR format for each mode within the packet envelopes shall be (TBR).

### 3.2.1.4 Earth Location Requirements

SRDA3.2.1.4-1
The APS shall meet the mapping uncertainty requirements of all primary EDRs using the scientific geolocation algorithms (adopted, adapted, or developed by the contractor).

SRDA3.2.1.4-2
Spacecraft and spacecraft/payload interface characteristics may contribute to geolocation errors. The UIID shall detail the spacecraft and spacecraft/payload requirements necessary to meet the mapping uncertainty requirements of the primary EDRs (TBR).

### 3.2.1.5 Algorithms

3.2.1.5.1 Scope

SRDA3.2.1.5.1-1
For all primary EDRs, the APS shall use scientific algorithms that have been adopted, adapted, or developed by the APS contractor. (See Section 3.2.1.1.1.) Adopting an algorithm means using an existing algorithm without change. Adapting an algorithm means using an existing algorithm with some modification, such as different values of coefficients, inclusion of higher order corrections, fusion of additional data sources, etc.

SRDA3.2.1.5.1-2
For all intermediate level data products used to generate the primary EDRs (such as cloud masks, snow/ice masks, SDRs, and flags indicating data quality, daytime versus nighttime, clear versus cloudy, etc.) the APS shall use scientific algorithms that have been adopted, adapted, or developed by the APS contractor. Because the APS contractor is not responsible for the content or format of operational SDRs, the APS contractor may select the appropriate intermediate-level data products needed as inputs to the scientific EDR algorithms in satisfying this requirement. The description of operational SDRs in Section 3.2.1.2 is provided as guidance. Algorithms need not be provided for data products that are generated by other sensor suites and used as inputs to the algorithms for APS primary EDRs.

3.2.1.5.2 Performance Requirements

SRDA3.2.1.5.2-1
The APS shall meet EDR thresholds and shall be no worse than the performance of algorithms used for current operational data products for these EDRs, if such operational products exist.

SRDA3.2.1.5.2-2
The Contractor shall provide an Algorithm Theoretical Basis Document (ATBD) for the assigned set of Primary EDRs. ATBDs provide the physical theory and assumptions behind the EDRs, as well as the mathematical procedures required to produce the RDRs, convert the RDRs into the SDRs, and convert the SDRs into the EDRs. The ATBD should discuss limitations on the approach, accuracy considerations, additional information required for measurement processing (mandatory and desirable), and alternative processing approaches required under alternative measurement situations (e.g., daytime and nighttime observations).

SRDA3.2.1.5.2-3
The Contractor shall provide research grade source code implementing the algorithm(s) described in the ATBD that address the primary EDRs. The research grade code should

include all processes, other than input/output, needed to: convert RDRs into SDRs; convert SDRs into EDRs; use all mandatory outside data; use of any optional outside data, if available; select alternative processing algorithms based on the data available; provide continuing calibration validation; and any other similar processing tasks required to satisfy allocated EDR quality and availability requirements. The scientific algorithms provided by the contractor may be adopted or adapted from existing algorithms, or developed, as needed.

3.2.1.5.3 Operational Algorithm Teams (OATs)

The government's Operational Algorithm Teams (OATs) may recommend scientific algorithms. These teams have contributed to the definition of the instrument requirements of Section 3. The OATs may also provide advisory information on APS functional and calibration requirements.

3.2.1.5.4 Convertibility to Operational Code

The government considers the SDR and EDR algorithms adopted, adapted, or developed by the APS contractor to be scientific, rather than operational, algorithms. The APS contractor is not responsible for identifying or developing operational SDR and EDR algorithms for the APS. (Any operational algorithms necessary for the generation of RDRs will ultimately be the responsibility of the APS contractor, and the operational code implementing these algorithms will be part of the required flight software. This statement applies to the post-downselect phase of the APS program.)

SRDA3.2.1.5.4-1
The scientific SDR and EDR algorithms delivered by the APS contractor shall be convertible into operational code that is compatible with a 20 minute maximum processing time at either the Centrals or field terminals for the conversion of all pertinent RDRs into all required EDRs for the site or terminal, including those based wholly or in part on data from other sensor suites. The intent of this requirement is to preclude algorithms that are so computationally intensive that any foreseeable implementation would stress or exceed the time available for delivery of EDRs in an operational environment.

SRDA3.2.1.5.4-2
The means by which the contractor shall validate the requirement that scientific algorithms be convertible to operational code subject to the constraint specified in SRDA3.2.1.5.4-1 is TBR.

SRDA3.2.1.5.4-3
The availability of any inputs required from ancillary sources to generate data products shall also be adequate to allow EDRs to be generated at the Centrals and field terminals within the time constraint specified in SRDA3.2.1.5.4-1.

3.2.1.5.5 Multiple Sensor Requirements

SRDA3.2.1.5.5-1
The contractor shall identify any constraints on the relationships between sensors within APS (if APS is comprised of more than one sensor) or between sensors in different sensor suites that are entailed by the contractor's algorithms for the APS primary EDRs. Such constraints might include, for example, relative pointing knowledge, relative pointing accuracy, co-boresighting, synchronization, etc. Based on this information and the corresponding information from other sensor contractors, the government may impose modified or additional requirements on the APS and/or other sensor suites. (See Sec. 3.2.2.)

### 3.2.1.6 Data Formatting and Compression

SRDA3.2.1.6-1
The data packets generated by the APS shall conform to the Consultative Committee for Space Data Systems (CCSDS) packetization per CCSDS 701.0-B-2, the data interface specification in accordance with the 1553 Interface Requirements Document (IRD) referenced in the GIID.

SRDA3.2.1.6-2
If data compression techniques are used by the APS , the compression shall be lossless.

## 3.2.2 PHYSICAL AND INTERFACE CHARACTERISTICS

In accordance with the GIID, the spacecraft-to-sensor interface requirements are broken down into four primary groups: mechanical, power, data, and thermal. In addition, environmental, software, testing, contamination, launch environment, and safety requirements are defined.

For some interface requirements, threshold and objective values are provided below. The objective values represent the lowest realistic values developed during initial studies at the Integrated Program Office (IPO). The threshold values represent the maximum acceptable values for the APS instrument.

SRDA3.2.2-1
The total APS mass (including all subsystems, deployment mechanisms, mounting hardware, cabling, etc.) shall not exceed the Threshold value given below:

| APS Mass | Kg |
|---|---|
| Objective | 25 |
| Threshold | 60 |

SRDA3.2.2-2
The dimensions for the stowed APS (including all subsystems, deployment mechanisms, mounting hardware, cabling, etc.) shall not exceed the Threshold values (TBR) given below:

| APS Dimensions | Velocity Direction (cm) | Nadir Direction (cm) | Anti-Solar Direction (cm) |
|---|---|---|---|
| Objective | 42 | 39 | 41 |

| | | | |
|---|---|---|---|
| Threshold | 70 | 41 | 70 |

Dimensions of components mounted internal to the spacecraft bus are TBD.

SRDA3.2.2-3
The total power consumption for the APS shall not exceed the Threshold value (TBR) given below:

| APS Power | Watts |
|---|---|
| Objective | 25 |
| Threshold | 45 |

If power varies throughout the daily cycle, power should be described with an orbital profile to express the power usage.

SRDA3.2.2-4
The total output data rate (orbit average) of the APS after data compression, if applicable, shall be less than or equal to 130 (TBR) kilobits per second.

SRDA3.2.2-5
The total output data rate (peak) of the APS after compression, if applicable, shall be less than or equal to 300 (TBR) kilobits per second.